The Thermal Extension of the Schwarzschild Metric:
Temperature as a Geometric Coordinate at Black Hole Horizons

Judicael Brindel
Independent Researcher, Cotonou, Benin
ORCID: 0009-0007-4590-9874

March 14, 2026

Abstract

We conjecture that the Schwarzschild metric is incomplete near black hole horizons because it omits temperature as a geometric coordinate. In the standard metric, temperature appears only as an observable effect — the Unruh temperature — not as a dynamical degree of freedom of the geometry itself. We propose an extension in which temperature T enters the metric explicitly, activating only when $T \geq T_{\text{conv}}$, a conversion threshold. Far from the horizon, the standard Schwarzschild metric is recovered exactly. Near the horizon, three parameters evolve simultaneously: time slows progressively, position approaches r_s, and temperature diverges. Rather than producing a singularity, this convergence triggers a phase transition — the conversion of ordinary matter into Penetrons [1] — whose outgoing flux constitutes Hawking radiation. The black hole singularity at $r = 0$ is not a physical reality but an artifact of the omission of temperature from the geometric framework. This paper is explicitly speculative.

Contents

1 Motivation **2**

2 Temperature as a Geometric Coordinate **2**
2.1 The Unruh temperature near the horizon 2
2.2 The three coupled parameters 2

3 The Extended Metric **3**
3.1 Recovery of standard general relativity 3
3.2 Activation at the horizon 3

4 Phase Transition Instead of Singularity **4**
4.1 Resolution of the singularity 4

5 Connection to the Penetron Conjecture **4**

6 Open Problems 5

7 Discussion and Scope 5

1 Motivation

The Schwarzschild metric governs the geometry of spacetime outside a spherically symmetric mass M:

$$ds^2 = -\left(1 - \frac{r_s}{r}\right) c^2 dt^2 + \left(1 - \frac{r_s}{r}\right)^{-1} dr^2 + r^2 d\Omega^2 \tag{1}$$

where $r_s = 2GM/c^2$ is the Schwarzschild radius. This metric has two well-known features at the horizon $r = r_s$:

1. The coefficient of dt^2 vanishes — time slows to zero for an external observer
2. The coefficient of dr^2 diverges — a coordinate singularity at the horizon

And at $r = 0$, the metric produces a physical singularity where all quantities diverge. General relativity breaks down there — the theory reaches its own limits.

We propose that this breakdown is not a fundamental feature of nature but a consequence of an omission: the temperature T has not been included as a geometric coordinate. In zones far from black holes, temperature is negligible and the omission is harmless. Near the horizon, where the Unruh temperature $T_{\text{Unruh}} \to \infty$, the omission becomes critical.

2 Temperature as a Geometric Coordinate

2.1 The Unruh temperature near the horizon

The Unruh effect establishes that an accelerating observer perceives a thermal bath at temperature:

$$T_{\text{Unruh}}(r) = \frac{\hbar c^3}{8\pi G M k_B} \cdot \frac{1}{r - r_s} \tag{2}$$

For $r \gg r_s$, $T_{\text{Unruh}} \approx 0$ — temperature is negligible. For $r \to r_s$, $T_{\text{Unruh}} \to \infty$ — temperature diverges.

In standard general relativity, this temperature is an observable effect, not a geometric degree of freedom. The metric $g_{\mu\nu}$ does not depend on T. We conjecture that this is the source of the singularity problem.

2.2 The three coupled parameters

Near a black hole horizon, three parameters evolve simultaneously and are not independent:

$$\begin{cases} t \to \text{slows progressively (gravitational time dilation)} \\ r \to r_s \quad \text{(position approaches horizon)} \\ T_{\text{Unruh}}(r) \to \infty \quad \text{(temperature diverges)} \end{cases} \tag{3}$$

As an object falls toward r_s:

- Time does not stop — it slows continuously and progressively. For an infalling observer, proper time continues. For an external observer, the infalling object appears to freeze asymptotically at r_s.

- Position advances toward r_s — the curvature deepens.
- Temperature rises without bound — the local Unruh temperature diverges.

The three parameters are coupled through the geometry. They reach their limiting values together, not independently.

3 The Extended Metric

Conjecture 1 (Thermal Extension of Schwarzschild)**.** *[Open] The Schwarzschild metric must be extended by the addition of a thermal coordinate T:*

$$\boxed{ds^2 = -\left(1 - \frac{r_s}{r}\right) c^2 dt^2 + \left(1 - \frac{r_s}{r}\right)^{-1} dr^2 + \beta(r)\, dT^2 + r^2 d\Omega^2} \tag{4}$$

where the thermal coupling coefficient is:

$$\beta(r) = \frac{\hbar^2 c^6}{(8\pi G M k_B)^2} \cdot \frac{1}{(r - r_s)^2} \tag{5}$$

This coefficient vanishes for $r \gg r_s$ and diverges as $r \to r_s$, ensuring that the thermal coordinate activates only near the horizon.

3.1 Recovery of standard general relativity

Far from the horizon, $r \gg r_s$:

- $T_{\text{Unruh}} \approx 0$, so $dT \approx 0$
- $\beta(r) \cdot dT^2 \approx 0$
- The metric reduces exactly to Schwarzschild

General relativity is recovered as the limiting case of the extended metric when temperature is negligible. This is the condition satisfied throughout the observable universe except in the immediate vicinity of black hole horizons.

Remark 1. *The structure is analogous to the relationship between Newtonian gravity and general relativity. Newton is recovered as the limit of Einstein when velocities are small. Here, standard general relativity is recovered as the limit of the extended metric when temperature is small.*

3.2 Activation at the horizon

As $r \to r_s$, $\beta(r) \to \infty$. The thermal term $\beta(r)\, dT^2$ dominates the metric. The geometry is governed by temperature rather than by position or time.

This is the regime where the standard Schwarzschild description fails and the extended metric becomes essential.

4 Phase Transition Instead of Singularity

Conjecture 2 (Conversion Threshold). *[Open] There exists a critical temperature T_{conv} at which ordinary matter undergoes a phase transition into Penetrons [1]. The threshold condition is:*

$$T_{\text{Unruh}}(r) \geq T_{\text{conv}} \implies \textit{matter} \to \textit{Penetrons} \tag{6}$$

This transition occurs at a radius $r_{\text{conv}} > r_s$, before the singularity at $r = 0$ is reached.

The conversion is not an explosion. It is a progressive phase transition, triggered by the three coupled parameters reaching their critical values together:

$$\text{matter falls} \xrightarrow{t \text{ slows}, T\uparrow} T \geq T_{\text{conv}} \xrightarrow{\text{conversion}} \text{Penetrons} \xrightarrow{\text{outward}} \text{Hawking radiation} \tag{7}$$

Remark 2. *The time coordinate does not vanish during this process. It slows progressively as the object approaches r_s. The conversion occurs before time effectively freezes — in the regime where temperature dominates but time still advances, slowly, for the infalling observer.*

4.1 Resolution of the singularity

The singularity at $r = 0$ is never reached because the conversion occurs at $r_{\text{conv}} > r_s > 0$. The extended metric describes a smooth phase transition rather than a geometric breakdown.

Conjecture 3 (No Physical Singularity). *[Open] In the extended thermal metric, the curvature singularity of the standard Schwarzschild solution at $r = 0$ is replaced by a conversion surface at $r = r_{\text{conv}}$. No physical quantity diverges at this surface: the divergence of T_{Unruh} is the trigger for the phase transition, not a pathology of the theory.*

5 Connection to the Penetron Conjecture

The Penetrons produced by the conversion [1] emerge with properties determined by the extended metric at the conversion surface:

1. **Superluminal velocity**: In the regime $T \geq T_{\text{conv}}$, the effective speed of light is modified. Via the Geometric Light Confinement framework, $c(r, T) \neq c_0$ near the horizon. The Penetron is born in a regime where the speed limit is not c_0, which is why it can travel at $v > c_0$.

2. **Non-geodesic trajectory**: The Penetron inherits the outward momentum of the converted matter. Its trajectory is not governed by the geodesics of the standard Schwarzschild metric but by the extended thermal metric.

3. **Information carrier**: The conversion preserves the information of the infalling matter. The Penetron carries this information outward, providing a classical resolution of the black hole information paradox.

The Hawking temperature observed at infinity:

$$T_H = \frac{\hbar c^3}{8\pi G M k_B} \tag{8}$$

is the thermalized average of the Penetron emission from the conversion surface — the cooled remnant of the extreme temperature at r_{conv}.

6 Open Problems

1. **Value of T_{conv}**: What sets the conversion threshold? Is it related to the Planck temperature, the string scale, or a property of the Penetron?
2. **Derivation of $\beta(r)$**: The thermal coupling coefficient is motivated physically but not derived from first principles. A full derivation requires a quantum extension of the extended metric.
3. **Einstein equations in the extended metric**: What are the modified Einstein equations when $g_{\mu\nu}$ includes the thermal component? Does the stress-energy tensor acquire a thermal contribution?
4. **Christoffel symbols**: The extended metric generates new Christoffel symbols $\Gamma^{\mu}_{\nu\rho}$ that couple position and temperature. Computing these explicitly would determine the geodesics of the extended spacetime.
5. **Observational signature**: Does the conversion surface at r_{conv} produce a detectable deviation from the standard Schwarzschild predictions near the horizon? Could the Event Horizon Telescope detect such a deviation?

7 Discussion and Scope

This paper is explicitly speculative. The extended metric is a conjecture motivated by physical reasoning, not a derivation from an established framework. The central claim is modest: the omission of temperature as a geometric coordinate in the Schwarzschild metric may be the source of the singularity problem, and its inclusion may resolve it through a physical phase transition rather than a mathematical pathology.

General relativity remains valid and is recovered exactly in the limit $T \ll T_{\text{conv}}$. The extension proposed here does not contradict existing tests of general relativity — it modifies the theory only in the extreme regime near black hole horizons, where no direct test has yet been performed.

We present this as an open problem at the intersection of general relativity, thermodynamics, and the Penetron conjecture.

Acknowledgements

This work was developed independently in Cotonou, Benin, without institutional support. The core idea — that temperature should enter the Schwarzschild metric as a geometric coordinate — emerged from a conversation about the nature of black hole interiors on the evening of March 14, 2026. The author thanks the open-access infrastructure (Zenodo, Internet Archive) that makes independent research deposition possible.

References

[1] J. Brindel, "The Penetron Conjecture: Hypothetical Superluminal Non-Geodesic Particles and the Penetrability of Black Hole Event Horizons," Zenodo, DOI: 10.5281/zenodo.19002758 (2026).

[2] J. Brindel, "Gravitational Islands Connected by the Chaining Web," Zenodo, DOI: 10.5281/zenodo.19004438 (2026).

[3] J. Brindel, "The Unfolding Universe: A Geometric Alternative to the Big Bang Singularity," Independent preprint (2026).

[4] K. Schwarzschild, "Über das Gravitationsfeld eines Massenpunktes nach der Einsteinschen Theorie," *Sitzungsberichte der Königlich Preussischen Akademie der Wissenschaften* (1916).

[5] S. W. Hawking, "Breakdown of predictability in gravitational collapse," *Physical Review D* **14**, 2460 (1976).

[6] W. G. Unruh, "Notes on black-hole evaporation," *Physical Review D* **14**, 870 (1976).